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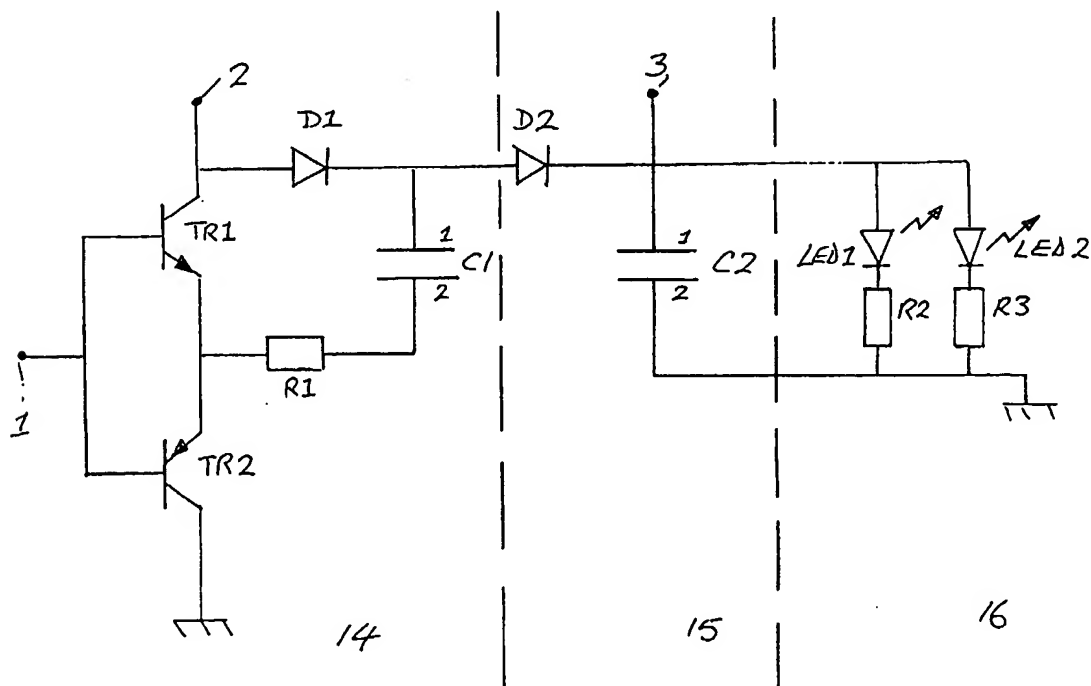
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UK CL (Edition T ) H2H HLL3  
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(54) Abstract Title  
Driver circuit for light emitting devices

(57) LED's are enabled to operate from the relatively low voltage power supplies of portable communications terminals. A push pull voltage booster 14 maintains charge on a charge reservoir 15 and LEDs 16 are connected in parallel with and draw current from the charge reservoir. The charge reservoir can be a number of capacitors of different capacitance to provide different operating voltages to each LED. An alternating signal input such as a square wave clocking sequence drives the push pull voltage booster. The amount of charge in the charge reservoir varies with the frequency of the alternating signal input.



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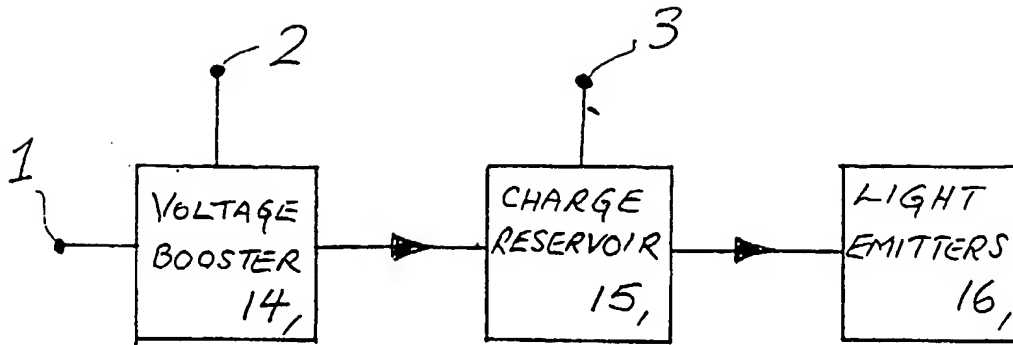


FIGURE 1

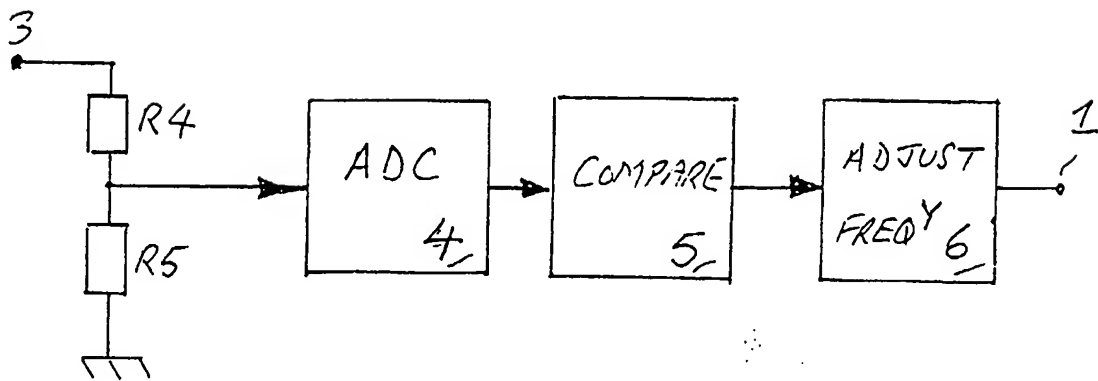


FIGURE 3

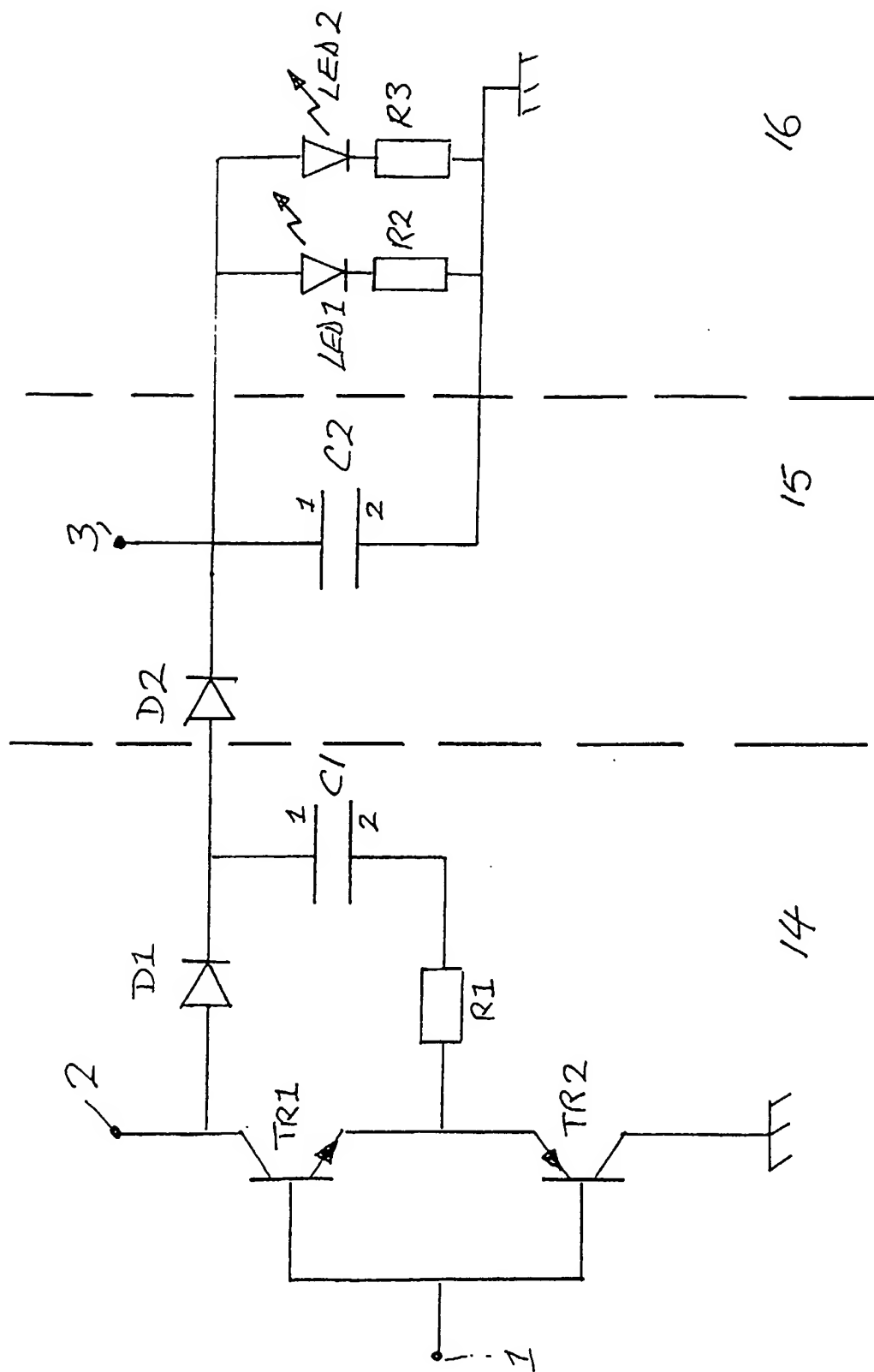


FIGURE 2

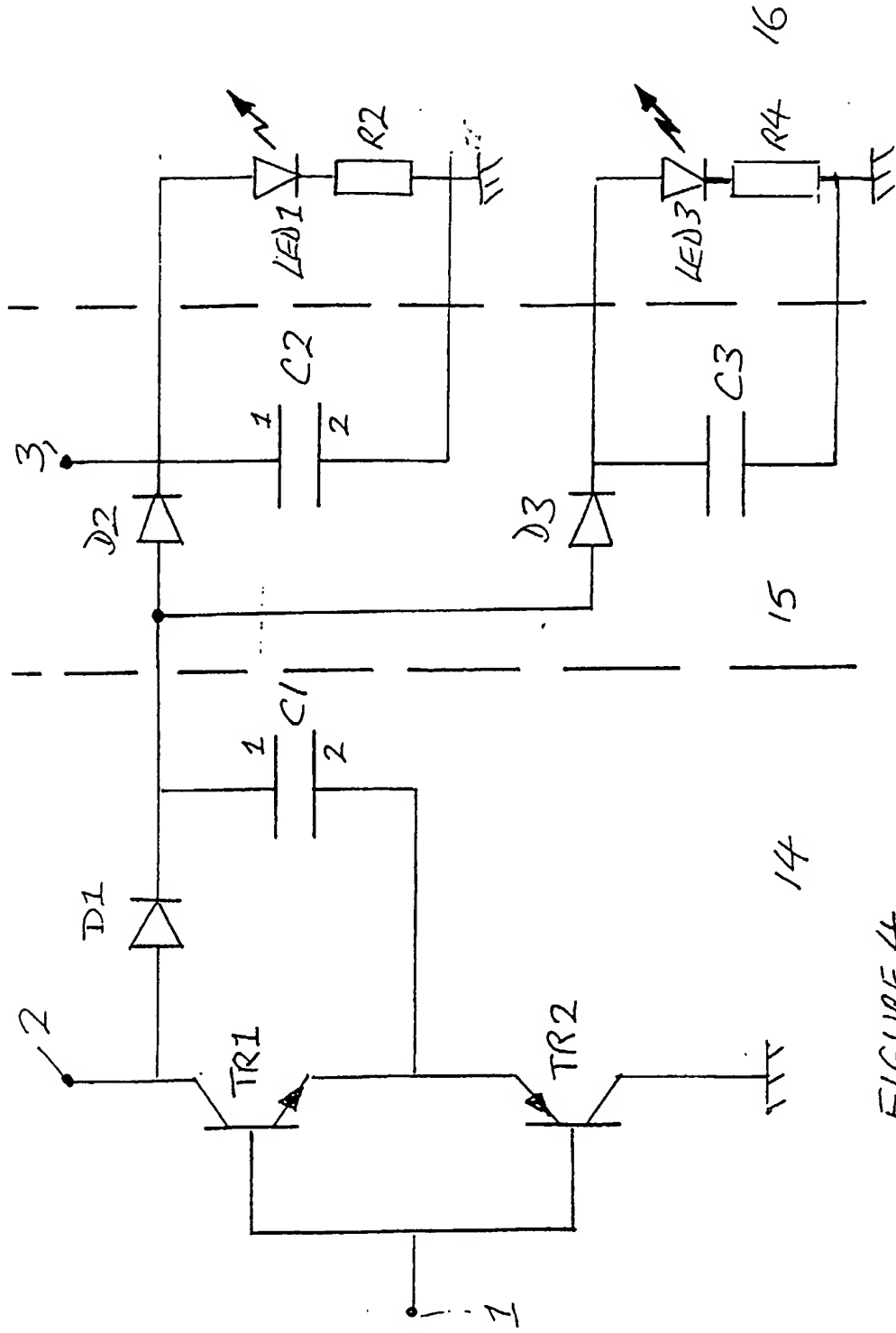


FIGURE 4

### **Driver circuit for light emitting devices.**

This invention relates to driver circuits for light emitting devices and it has particular utility for light emitting diodes in portable electronic terminals.

Light emitting devices such as light emitting diodes (LED) are presently favoured for illumination of displays in portable electronic terminals, e.g. mobile phones. In some lighting arrangements the LED's emit white light, which may then be filtered to provide various colours required for display illumination.

In order for the LED's to operate and emit light of the desired luminance a voltage across each device of 3.8 volts +/- 0.2 volts is required. The main power supply for a portable terminal is normally a re-chargeable battery having a nominal output voltage of 3.6 volts. Although these voltages may be different for particular types of devices and batteries, in general the battery supply voltage needs to be boosted in order to operate the LED's properly.

Despite considerable efforts by manufacturers in recent years to reduce the size and cost of portable terminals, pressures to reduce cost and size remain. The incorporation of additional features with their associated components within portable terminals also encourages displacement of a number of components from existing circuits.

It is an object of the present invention to provide a simple and economical but effective driver circuit for light emitting devices.

In accordance with the invention there is provided a circuit for driving light emitting devices comprising an alternating input to a voltage booster, the output from the voltage booster maintaining a charge reservoir and said charge reservoir connected in parallel with said light emitting devices.

An example of the invention is described below with reference to the accompanying figures in which like numerals identify equivalent elements and in which;

Figure 1 is a block diagram of a driver circuit according to the invention,

Figure 2 is a circuit diagram of an LED driver circuit for a mobile phone,

Figure 3 illustrates a means for control of the voltage across the light emitting elements.

Figure 4 is a circuit diagram of a driver circuit suitable for use with light emitting devices having different operating characteristics.

The basic elements of a driver circuit in accordance with the invention are illustrated in the block diagram of figure 1. A voltage booster **14** is supplied at terminal **2** with a regulated DC voltage and an alternating input signal, which may be a sinusoid, is applied to terminal **1**. The boosted voltage output from **14** enables a charge reservoir to be maintained at **15** and the voltage level of the charge reservoir is monitored at terminal **3**.

Light emitting devices **16** are connected in parallel with and are supplied from charge reservoir **15**.

With reference to figure 2, an LED driving circuit suitable for a mobile phone is shown in detail. The alternating input to the voltage booster **14** is applied to terminal **1**. Conveniently a square wave clocking signal is used as the input applied to terminal **1** when the light emitting devices LED **1** and LED **2** are to be lighted. This would occur for example when a call is received at the terminal or when a key on the keypad is pressed by the user. A suitable clocking signal is normally readily available from a processor within portable communication terminals.

A 2.8 volt regulated supply is applied to terminal **2**. This supply is readily available as it is used normally within the phone for supplying the baseband digital processing circuits. The clocking input at terminal **1** is connected to the base of transistor TR1 and to the base of transistor TR2. TR1 is a NPN transistor and TR2 a PNP transistor forming together the circuit arrangement known as push pull.

When the input clock is low, transistor TR1 is non-conducting and transistor TR2 is turned on grounding one side of capacitor C1 (lower plate C1/2). Capacitor C1 then charges via diode D1 and the upper plate C1/1 reaches 2.6 volts. When the input clocking voltage goes high transistor TR1 switches on and transistor TR2 switches off. The lower plate C1/2 of capacitor C1 is pulled to 2.2 volts via transistor TR1 and as capacitor C1 charges, the voltage on the top plate C1/1 of the capacitor reaches 4.6 volts. When C1/1 is at 4.6 volts, charge is transferred from capacitor C1 to the

output capacitor C2 through diode D2. Output capacitor C2 is connected in parallel with and supplies current to the light emitting diodes LED 1 and LED 2.

The amount of charge in the charge reservoir varies with the frequency of the alternating input. Therefore alteration of the frequency of the clocking input will affect the amount of charge transferred to capacitor C2. A reduction in frequency with a corresponding reduction in charging rate of capacitor C2 will reduce the voltage across C2. The lower voltage across LED 1 and LED 2 will cause them to draw less current and equilibrium is established such that the current drawn by the LED's equates to the charging rate of capacitor C2. By this means the brightness of the LED's will be varied.

Although two LED's are shown in the circuit, additional LED's may be connected in parallel with LED 1 and LED 2, the total number being limited by the capacity of the charge reservoir 15. The resistor R1 is not essential to the operation of the circuit but is included to smooth the edges of the switching waveform and reduce noise. The regular clocking input at terminal 1 may be replaced with a variable input such as a pulse width modulated (PWM) alternating signal. A reduction in the duty cycle of the PWM waveform will reduce the output voltage and the brightness of the LED's will be reduced.

Control of the voltage level across the LED's may be achieved by monitoring of the voltage at terminal 3 of figure 2. Amongst other things control of the voltage level compensates for changes due to ageing and

tolerance variations. A means for adjusting the voltage level across the LED's is illustrated in figure 3. The voltage level control means comprises a voltage divider connected to an analogue to digital converter (ADC) , a comparison of ADC output with a set value and adjustment of the frequency of the alternating input when the ADC output and the set value differ.

The voltage at terminal 3 is applied to voltage divider R4/R5 and the output from the voltage divider is fed to an analogue to digital converter 4 which provides a digital output corresponding to the voltage across the LED's. The digital output is then compared in comparator 5 with a single value set to produce the required voltage. Variation of the digital output from the set value produces an output from comparator 5.

An output from comparator 5 produces an adjustment of the frequency (or duty cycle for PWM) at 6 to the alternating input of the voltage booster circuit. The change in the frequency of the alternating input acts to bring the voltage at terminal 3 and the corresponding digital output from the monitor into register with the set value. Additionally the set value may be selected from a series of values corresponding to different illumination requirements either automatically or in response to user inputs.

Illumination levels may therefore be set to respond to ambient light levels, to vary according to the calendar and time of day, or to be set according to the preferences of a user.

A known technique for reducing the noise levels associated with a fixed duty cycle of a PWM waveform may be implemented. A pseudo random

variation in the PWM provides for sufficient charge to be maintained in the charge reservoir while spreading the noise over a wider spectrum.

Electromagnetic emissions may also be reduced by this means.

The luminance of the LED's remains unaffected by reduction of battery power until the reduction in power causes the phone to cease functioning.

The LED's connected in a circuit as shown in figure 2 would normally be matched such that they had essentially the same operating characteristics, in particular the same forward voltage. With reference to figure 4, a driver circuit suitable for use with light emitting devices having different operating characteristics is shown. The voltage booster **14** operates as described above in relation to figure 2. The charge reservoir **15** of figure 4 is shown as comprising two elements with capacitor C2 charging through diode D2 and capacitor C3 charging through diode D3. Generally the charge reservoir may comprise a plurality of elements.

The first light emitting device LED1 is connected across C2 and the second light emitting device LED 3 is connected across C3. The voltages across both C2 and C3 will vary according to their capacitance and therefore the forward voltage characteristic of each LED can be accommodated by selection of the associated capacitor. More than one LED may be connected in parallel with C2 or C3.

## Claims

1. A circuit for driving light emitting devices comprising an alternating input to a voltage booster, the output from the voltage booster maintaining charge in a charge reservoir and said charge reservoir connected in parallel with said light emitting devices.
2. A circuit for driving light emitting devices as in claim 1 in which the charge reservoir comprises a plurality of elements of different capacity and each of said elements connected in parallel with one or more light emitting devices.
3. A circuit for driving light emitting devices as in claims 1 or 2 in which the amount of charge in the charge reservoir varies with the frequency of the alternating input.
4. A circuit for driving light emitting devices as in claims 1 to 3 in which the voltage booster is a push pull circuit.
5. A circuit for driving light emitting devices as in claims 1, 3 or 4 in which the charge reservoir is a capacitor charging through a diode.
6. A circuit for driving light emitting devices as in claims 2, 3 or 4 in which elements of the charge reservoir are connected in parallel and comprise capacitors charging through diodes.

7. A circuit for driving light emitting devices as in any preceding claim in which the alternating input is a square wave clocking voltage.
8. A circuit for driving light emitting devices as in claims 1 to 6 in which the alternating input is a pulse width modulated waveform.
9. A circuit for driving light emitting devices as in any preceding claim in which the light emitting devices are LED's.
10. A circuit for driving light emitting devices as in any preceding claim having a voltage level control means comprising a voltage divider connected to an ADC, a comparison of ADC output with a set value and adjustment of the frequency of the alternating input when the ADC output and the set value differ.
11. A voltage level control for a circuit for driving light emitting devices as in claim 8 in which the set value is selected from a series of values.
12. A circuit for driving light emitting devices substantially as hereinbefore described with relation to, or as illustrated in figures 1 to 4.



**Application No:** GB 0124865.7  
**Claims searched:** All

**Examiner:** Rowland Hunt  
**Date of search:** 20 June 2002

## **Patents Act 1977**

### **Search Report under Section 17**

#### **Databases searched:**

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.T): H2H (HLL3)

Int Cl (Ed.7): H05B 33/08

Other: Online: EPODOC, JAPIO, WPI

#### **Documents considered to be relevant:**

Category	Identity of document and relevant passage	Relevant to claims
	NONE	

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
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